



Discrete Event Component Architecture for Modeling Ships

Arnie Buss
Research Associate Professor
MOVES Institute
abuss@nps.edu

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Overview



- Objectives
- Sprint Through Component-Based Discrete Event Methodology
- Component Architecture for DES Modeling of Ships
- Status
- Next Steps

Objectives



- Analysis-oriented
 - Evaluate good or ideal force levels
 - Compare Tactics
 - Evaluate new platforms in operational setting
 - Evaluate new ship systems in operational setting
- Make changes or modifications to existing systems

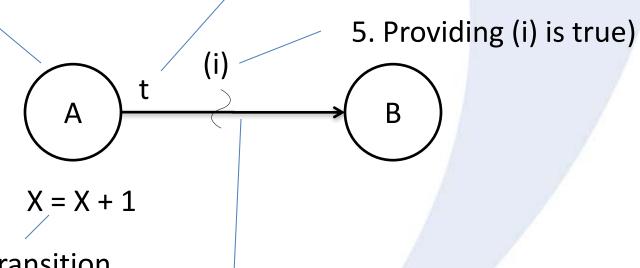


Event Graph



1. Event A occurs

4. t time units in the future

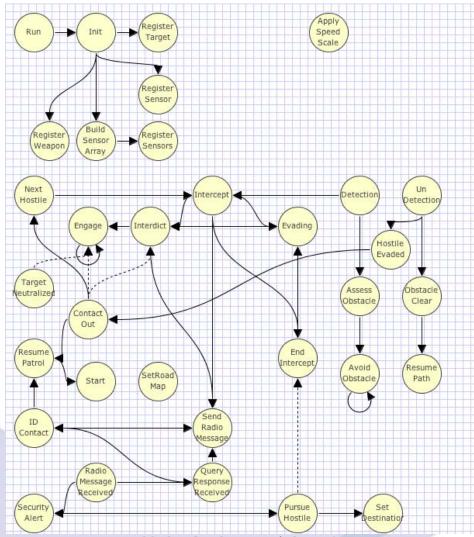


2. Causing State Transition

3. Then schedules Event B



Example





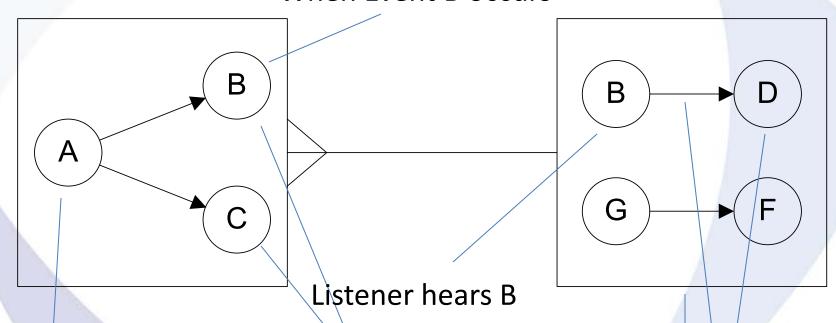


- Each component encapsulates its own
 - States
 - Event Graph Parameters
 - Event Graph





When Event B occurs



Event A Occurs

Scheduling B & C

Listener "hears" A
But has no match

And schedules D





- Increases scaleability
- Functional decomposition
- Loose coupling
- Reuse
- Flexibility

Ship Operational Components



- Movement
- Tactics/Behavior
- Sensing
- Weapons
- Communication
- Containers

Key Criteria for Level of Detail



- Relevance to questions being asked of model
 - Is it necessary to answer questions?
- Does it impact any estimated measures?
 - Does more detail answer question any better?
- Ideal level of detail
 - As simple as possible
 - But no simpler
- Components allow for simple implementation of multi-level resolution

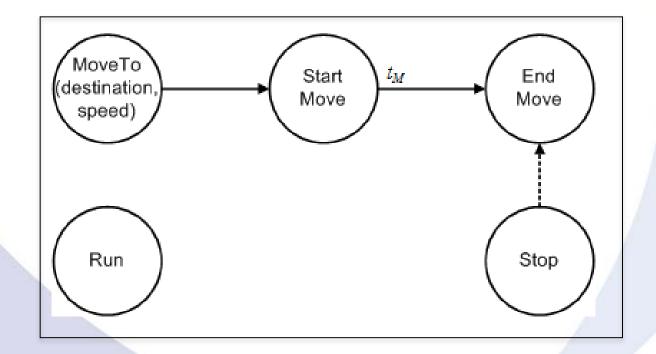
Modeling Movement



- Location cannot be DES state
- However, all movement can be described by an equation of motion
- Example: constant velocity $x(t) = x_0 + (t t_0)v$
- DES state is initial conditions: (t_0, x_0, v)

Mover Event Graph Component





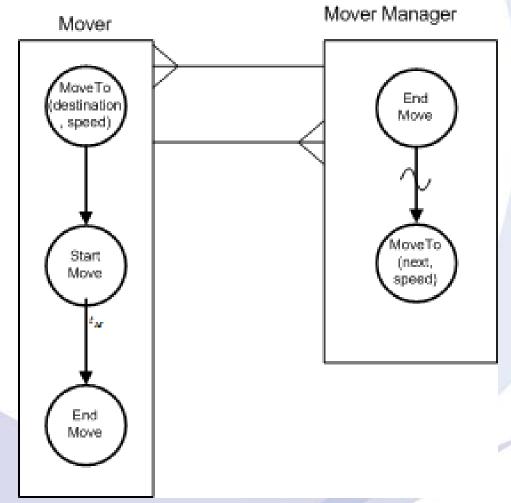




- Separate movement rule from movement logic
- Use listening to schedule next move
- Easy to define new movements rules
- Examples
 - PathMoverManager
 - PatrolMoverManager
 - RandomMoverManager







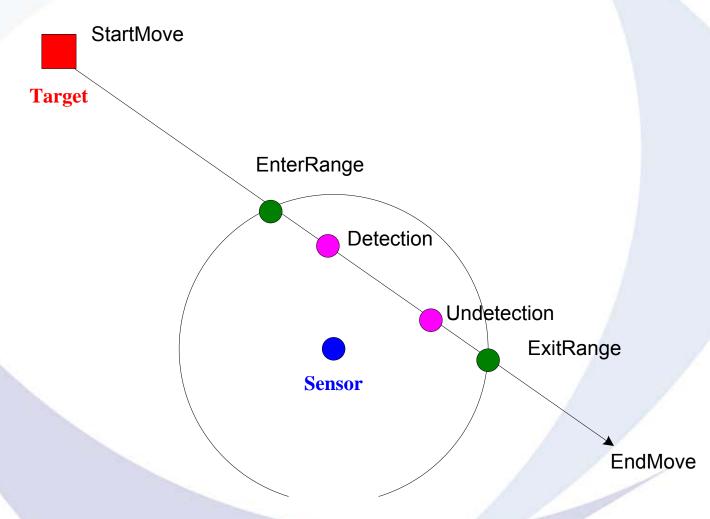
Sensing



- Detection only possible within "maximum range" of sensor
- Outside range, no interactions
- Canonical Event Sequence:
 - Enter Range
 - Detection
 - Undetection
 - Exit Range

Canonical Sequence









Time to Enter/Exit Range:

$$t = -\frac{x \cdot v}{\|v\|^2} \pm \frac{\sqrt{\|v\|^2 (R^2 - \|x\|^2) + (x \cdot v)^2}}{\|v\|^2}$$

Detection



- After Range is entered, Detection occurs sometime later
- Examples
 - Cookie Cutter: delay = 0.0
 - Constant Rate: delay $\sim \text{Exp}(\lambda)$
 - Other distributions (e.g. Gamma)
 - Glimpse: Every Δt , Detection w/prob p(...)





- Three types of objects
 - Sensor classes
 - Referee class
 - Mediator classes
- Referee responsible for Enter/Exit Range
- Mediator responsible for Detection/Undetection
- Each Sensor/Target/Mediator triple implements a detection algorithm

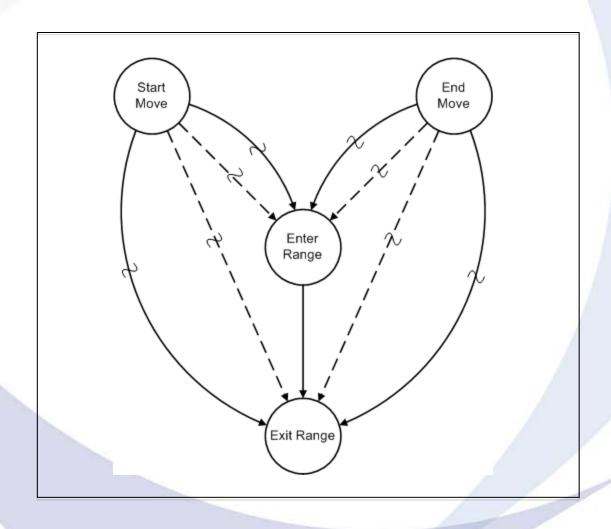
Referee



- Responsible for computing & scheduling EnterRange and ExitRange events for all registered sensor/target pairs
- EnterRange events cause the appropriate Mediator to be tasked with adjudicating the actual detection
- Multiple instances of Referee can capture different "bandwidths"



Referee Event Graph



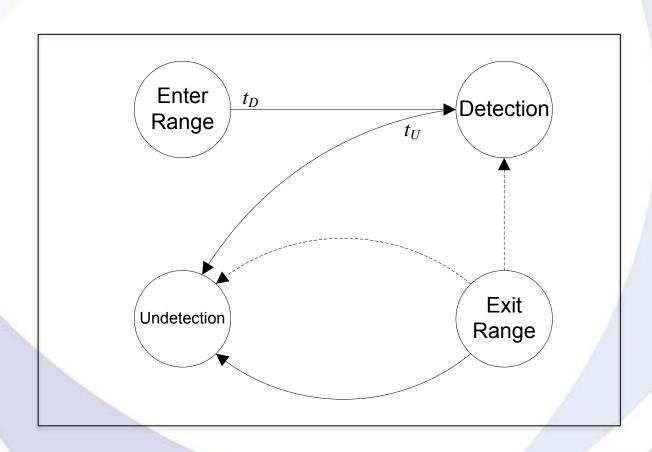
Mediator



- Can implement different detection algorithms for every Sensor/Target pair
 - Can have given Sensor use one algorithm for one type of target and another for a different type of target
- Simple to implement
- Configure MediatorFactory
- Makes implementing new algorithms easy

Mediator Event Graph





Basic Organization of Platform

Behaviors

Sensor1

Sensor2

Sensor3



Multiple Weapons Systems

Weapon System 2

Weapon System 1

Weapon System 3

MoverManager1

MoverManager2

Mover

Behaviors based on perception

Multiple Sensors

One Mover Component

Multiple Mover

Managers.

(Only 1 Active at

any time.)

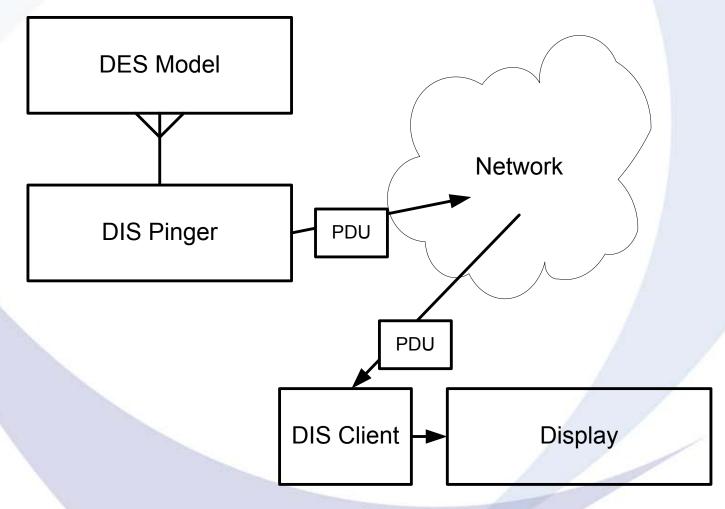




- Simkit (Java)
- Viskit (XML/Java)
- SimPykit (Python)

Loose Coupling Between Model and Display (DIS)









- Hand-crafted 2-D (one-offs)
- XJ3D
- Delta3D (Under Construction)
 - Using DIS
 - SimPykit using Python bindings

Status



- Framework complete for:
 - Movement
 - Movement tactics
 - Sensing
 - Hooks for behavioral response
 - Simple behaviors
- To be done:
 - Complete design of behavioral components
 - Complete first-level implementation (code)





- Continue work on modeling behavior and tactics
- Complete design of complex components
- First version of TCraft platform as exemplar
- Work towards complete (modeler-friendly) simulation





Questions?



Arnie Buss Research Associate Professor

MOVES Institute abuss@nps.edu